Influence of a Threaded Implant Design and Manufacturing on Osseointegration

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Purpose: The purpose of this study was to evaluate how different design features and manufacturing methods influence implant osseointegration and mechanical properties associated with fixation in the cancellous bone of adult sheep.

Introduction. Iliosacral screw fixation has become commonplace for unstable posterior pelvic ring fractures and widely used for patients with chronic sacroiliac joint pain. Standard screw fixation can lead to screw backout with the repetitive cyclic motion across an unfused joint. Strategies have included surface coating, porous ingrowth surface technology and fenestrations for through growth. This study evaluated how different design features and manufacturing methods influence implant osseointegration and mechanical properties associated with fixation in the cancellous bone of adult sheep.

Methods: This study evaluated the in vivo performance of 3 titanium alloy implants: A) Machined Screw B) Fenestrated Sacroiliac Device C) iFuse TORQ in the distal femur and proximal tibia in 8 sheep using an established model. Groups A and B were made with traditional methods while Group C was produced using additive manufacturing (3D printing). The vivo responses of the implants at the implant-bone interface were examined using mechanical testing (push out and removal torque), PMMA histology combined with fluorochrome labels and quantitative histomorphometry of bone ongrowth, ingrowth and through growth at 3 and 6 weeks.

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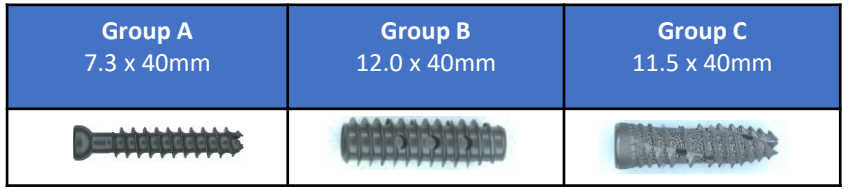
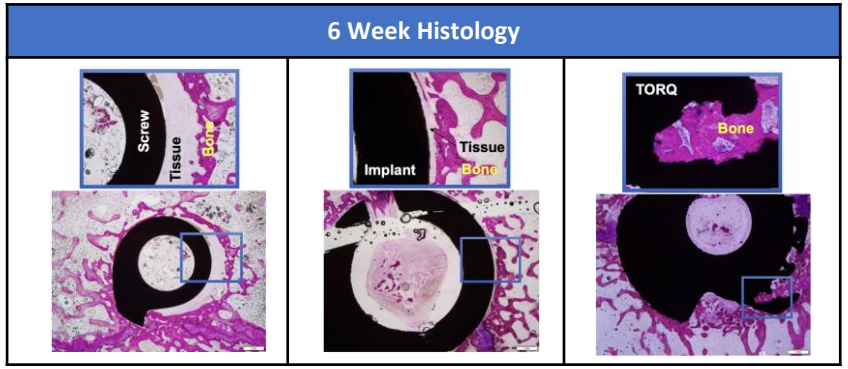
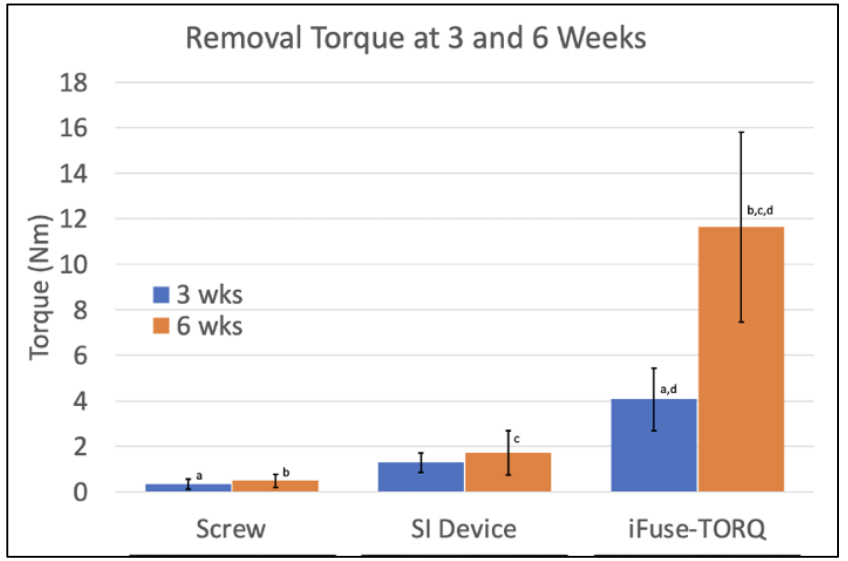
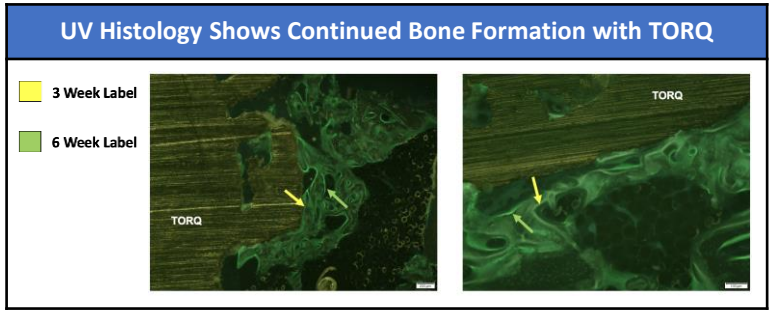






Results: Removal torque at 3 and 6 weeks statistically improved with time and group C was statistically greater compared to the other groups which did not increase with time. Shear stress push out data did not differ between groups. New bone formed directly on all groups and no adverse reactions were noted. Osseointegration via ongrowth, ingrowth and through growth was a function of implant design. The 3D printed surface in group C was rougher and outperformed traditional manufacturing surfaces of groups A and B. The porous domains and fenestrations in the design of group C allowed for bone ingrowth and through growth which accounted for the superior mechanical properties.



Conclusions. Osseointegration can be achieved with a combination of 3 mechanisms: bone ongrowth, bone ingrowth, and bone through growth. Implant design determines how these three osseointegration opportunities can be exploited to achieve implant stability in the short as well as longer term. Implant designs that provide osseointegration via ongrowth, ingrowth and through growth improve implant fixation. This may have important implications in longer term implant stability and clinical outcomes in their use. For treatment of acute posterior pelvic injuries or degenerative sacroiliac joint, the improved initial fixation of this novel implant has important implications for providing improved long-term stability.